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TECHNICAL MEMORANDUM

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STATIC LONGITUDINAL AND LATERAL AERODYNAMIC

CHARACTERISTICS AT A MACH NUMBER OF 2.20

OF A VARIABLE-WING-SWEEP

STOL CONFIGURATION

By Gerald V. Foster and Odell A. Morris

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WASHINGTON October 1960

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

TECHNICAL MEMORANDUM X-329

STATIC LONGITUDINAL AND LATERAL AERODYNAMIC CHARACTERISTICS AT A MACH NUMBER OF 2.20 OF A VARIABLE-WING-SWEEP STOL CONFIGURATION*

By Gerald V. Foster and Odell A. Morris

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SUMMARY

An investigation has been conducted in the Langley 4- by 4-foot supersonic pressure tunnel at a Mach number of 2.20 to determine the aerodynamic characteristics of a variable-wing-sweep short take-off and landing (STOL) configuration with outboard panels swept back 50°, 75°, and 80°.

The results indicate that the longitudinal stability of the complete configuration decreased slightly with increase in lift. The static margin at zero lift decreased from 21.7-percent to 14.1-percent mean geometric chord with increase in sweep angle of the outboard wing panels from 50° to 80°.

These results in conjunction with transonic results for the same model, obtained from NASA TM X-321, indicate that the total change in static margin due to an increase of the Mach number from 0.60 to 2.20 combined with a change in wing sweep from 25° to 75° is about 11-percent mean geometric chord.

The complete configuration exhibited positive directional stability, positive effective dihedral, and a maximum untrimmed lift-drag ratio of approximately 4.6.

INTRODUCTION

The National Aeronautics and Space Administration is currently conducting configuration studies directed toward the development of a

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*Title, Unclassified.

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multimission airplane capable of STOL operation, maximum possible low-altitude range, and acceleration to supersonic speeds for short periods of time. Such demands require that the configuration possess efficient subsonic as well as supersonic flight characteristics. Since the requirements for efficient low-speed flights are not compatible with those for supersonic flight, the effort of these studies has been directed toward a configuration incorporating variable wing sweep with an outboard pivot. The available results of this study are presented in references 1 to 10.

This paper presents results of an investigation of a variable-wing-
sweep STOL configuration that has been reported on for transonic speeds L
in reference 11. The vertical take-off capability was eliminated from 1
this configuration in order to increase the high-speed capability. In 1
order to eliminate stability problems in the STOL phase, the two rotata- 7
ble nozzles of the present configuration were located near the airplane 7
center of gravity. The results include the longitudinal and lateral aerodynamic characteristics at a Mach number of 2.20 with the wing outer panel swept back 50°, 75°, and 80°.

SYMBOLS

Force and moment coefficients are referred to the body-axis system except the lift and drag coefficients which are referred to the wind-axis system. All data presented herein are based on the geometry of the wing with the outboard panels swept back 75°. The moment reference point is located on the body center line at a station 57.2 percent of the body length.

The coefficients and symbols are defined as follows:

C_D drag coefficient, $\frac{\text{Drag}}{qS}$

C_L lift coefficient, $\frac{\text{Lift}}{qS}$

C_m pitching-moment coefficient, $\frac{\text{Pitching moment}}{qS\bar{c}}$

C_l rolling-moment coefficient, $\frac{\text{Rolling moment}}{qSb}$

C_n yawing-moment coefficient, $\frac{\text{Yawing moment}}{qSb}$

C_Y side-force coefficient, $\frac{\text{Side force}}{qS}$

C_{l_β} effective-dihedral parameter, $\partial C_l/\partial\beta$

C_{n_β} directional-stability parameter, $\partial C_n/\partial\beta$

C_{Y_β} side-force parameter, $\partial C_Y/\partial\beta$

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L/D lift-drag ratio, C_L/C_D

S wing area including fuselage intercept

b wing span

$\bar{c}$ wing mean geometric chord

q free-stream dynamic pressure

α angle of attack, deg

β angle of sideslip, deg

δ_h horizontal-tail deflection, deg

Λ sweep angle of leading edge of outboard wing panels, deg

Model Component Designations

Model components are identified by the following designations:

W wing

B body

V vertical tail

H horizontal tail

MODEL AND APPARATUS

Details of the model are shown by drawings and photographs presented in figures 1 and 2, respectively. The model, one of a series of aircraft configurations currently being investigated, is referred to herein as model 3, to conform with the designation used in reference 11. This model is a refinement of model 2 reported on in reference 10. Modifications included in model 3 from model 2 are an increase in forebody length, a rearward shift of the side-jet exits and an improved area distribution (fig. 3). In addition, the base exit of model 3 was designed to operate in a fixed position; whereas, the two side exits were designed to rotate downward through an angle range of approximately 120° from straight back to about 30° ahead of the vertical for low-speed operation. The model had a total inlet-capture area of 0.0275 sq in., an area of 0.0133 sq in. for the 2 side exits, and a base exit area of 0.0133 sq in. The vertical and horizontal tails had 60° swept back leading edges, an aspect ratio of 1.25, and a taper ratio of 0.18. These tail surfaces were constructed of sheet metal having rounded leading edges and beveled trailing edges with a thickness ratio of 0.04.

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The wing used with model 3 had the same plan-form characteristics as the wing used with model 2. The inboard panels of the wing had NACA 65A004.5 airfoil sections (measured streamwise) and a leading-edge sweep angle fixed at 60°. The outboard panels had NACA 65A006 airfoil sections (measured streamwise with panels swept back 25°) and leading-edge sweep angles of 50°, 75°, or 80°.

The model was mounted on a remotely controlled rotary sting, and force measurements were made through the use of a six-component internal strain-gage balance.

TESTS, CORRECTIONS, AND ACCURACY

The test conditions are as follows:

Mach number	2.20
Stagnation temperature, °F	100
Stagnation pressure, lb/sq ft	1,440
Reynolds number based on $\bar{c}$ of wing with outer wing panels swept back 75°	1.47×10^6

The stagnation dewpoint was maintained sufficiently low (-25° or less) so that no condensation effects were encountered in the test section. The angle of attack and sideslip were corrected for deflection of the balance and sting under load. The pressure within the balance enclosure was measured, and the drag force was adjusted to a balance chamber pressure equal to free-stream static pressure. The internal drag was determined from the change in momentum from free-stream conditions to conditions measured at the duct exits. The average mass flow through the inlet was 1.088. The internal drag correction applied to the drag results presented herein varied from 0.0151 to 0.0172. In order to insure a turbulent boundary layer, 1/8-inch-wide strips of No. 80 carborundum grains were attached to the wing and tail surfaces at the 0.10-chord station and at a body station 3.25 inches rearward of the nose.

The estimated accuracy of the measured quantities is as follows:

C_L	± 0.0053
C_D	± 0.0011
C_m	± 0.0022
C_l	± 0.0002
C_n	± 0.0012
C_Y	± 0.0053
α, deg	± 0.1
β, deg	± 0.1
δ_h, deg	± 0.1

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PRESENTATION OF RESULTS

The results of the investigation and the figures in which they will be found are shown in the following table:

	Figure
Effect of the horizontal-tail deflection on the aerodynamic characteristics in pitch:	
$\Lambda = 50^{\circ}$	4
$\Lambda = 75^{\circ}$	5
$\Lambda = 80^{\circ}$	6
Aerodynamic characteristics in pitch for various combinations of components; $\Lambda = 75^{\circ}$	7
Variation of the aerodynamic characteristics in sideslip:	
$\Lambda = 50^{\circ}$	8
$\Lambda = 75^{\circ}$	9
$\Lambda = 80^{\circ}$	10

SUMMARY OF RESULTS

The variation of pitching moment with lift (figs. 4 to 6) indicates that the longitudinal stability of the complete configuration model 3 (wing-body-tail configuration) decreased slightly with increase in angle of attack for sweep angle of the outboard wing panels of 50°, 75°, or 80°. The static margin of the model ($C_L = 0$) for $M = 2.20$ decreased from 21.7 percent $\bar{c}$ to 14.1 percent $\bar{c}$ as the sweep angle of the outboard wing panels was decreased. These results, in conjunction with results of reference 11, indicate that the total change in static margin due to an increase in sweep angle from 25° to 75° combined with an increase in

Mach number from 0.60 to 2.20 amounts to about 11 percent $\bar{c}$. The minimum-drag coefficient of the model for $M = 2.20$ was 0.0335 for $\Lambda = 50^\circ$ and 0.0290 for $\Lambda = 75^\circ$ or 80°. The maximum untrimmed (L/D) ratio was approximately 4.6 or approximately 0.8 higher than model 2 of reference 2.

The summary of the lateral-stability characteristics presented in figure 11 indicates that the model was directionally stable and had positive effective dihedral for an angle-of-attack range up to approximately 9°. It may be noted from results presented in figures 8, 9, and 10 that the directional stability of the model at the highest angle of attack is limited to sideslip angles less than approximately 2°.

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Langley Research Center,
National Aeronautics and Space Administration,
Langley Field, Va., June 10, 1960.

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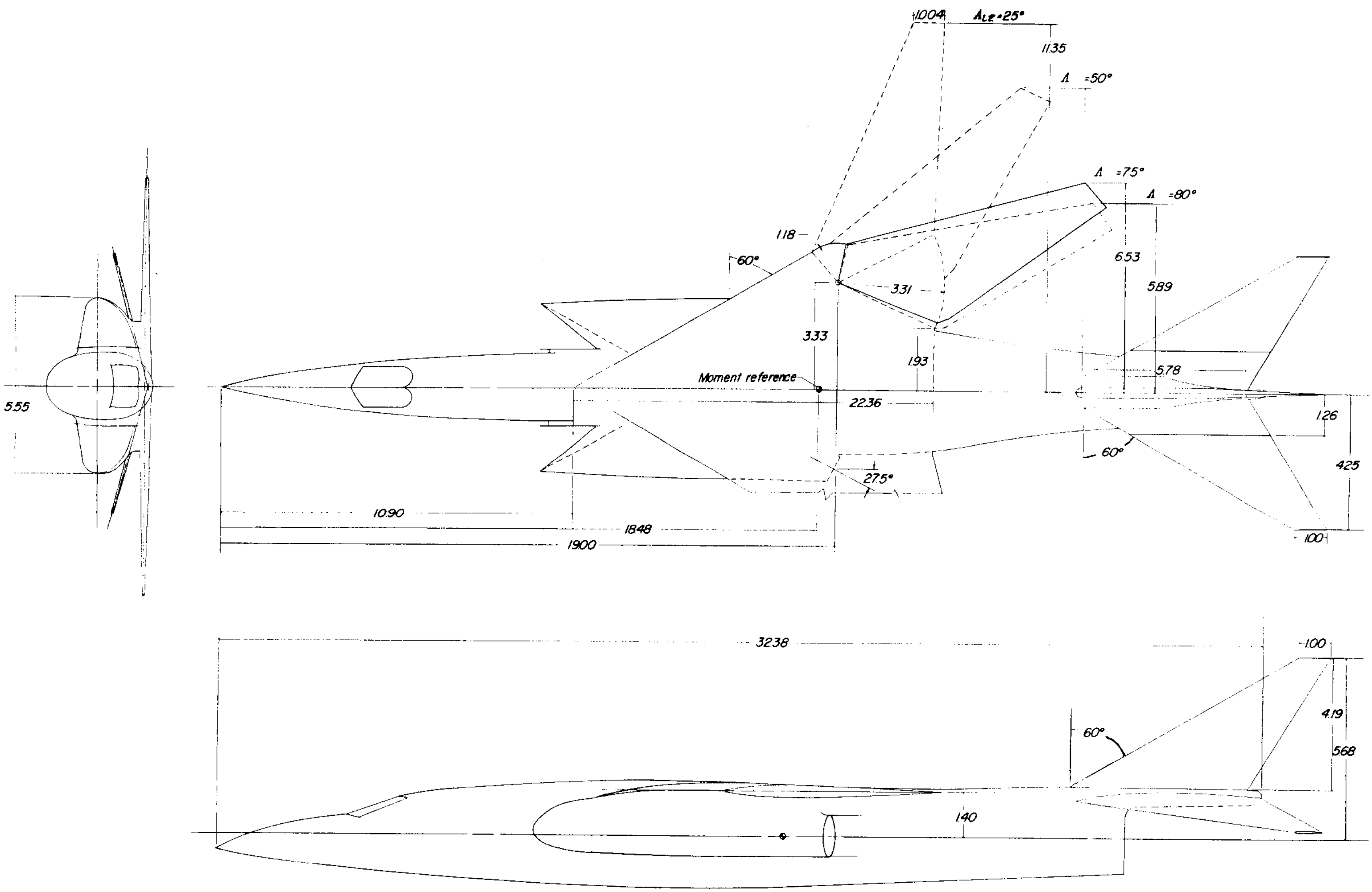
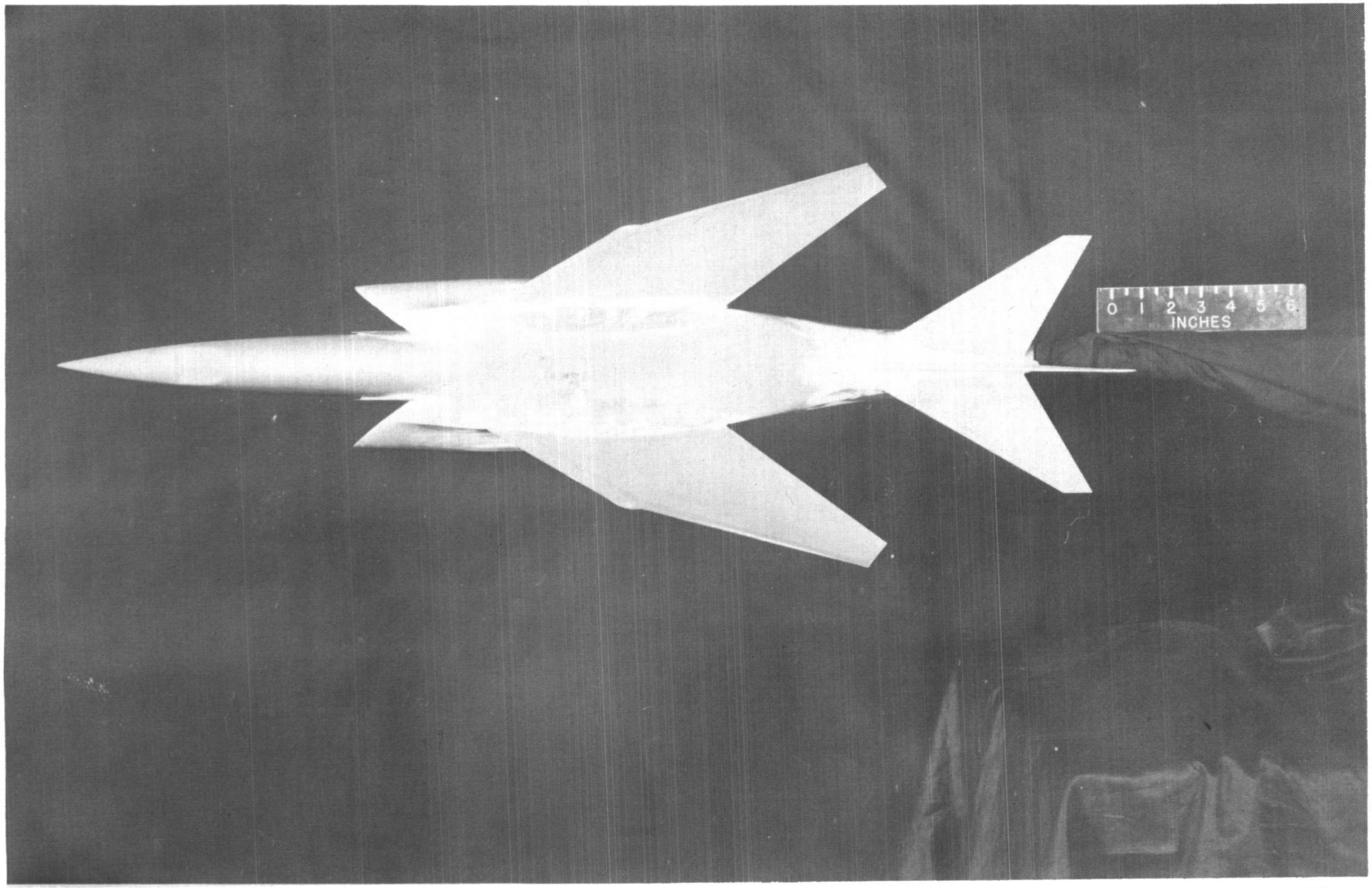
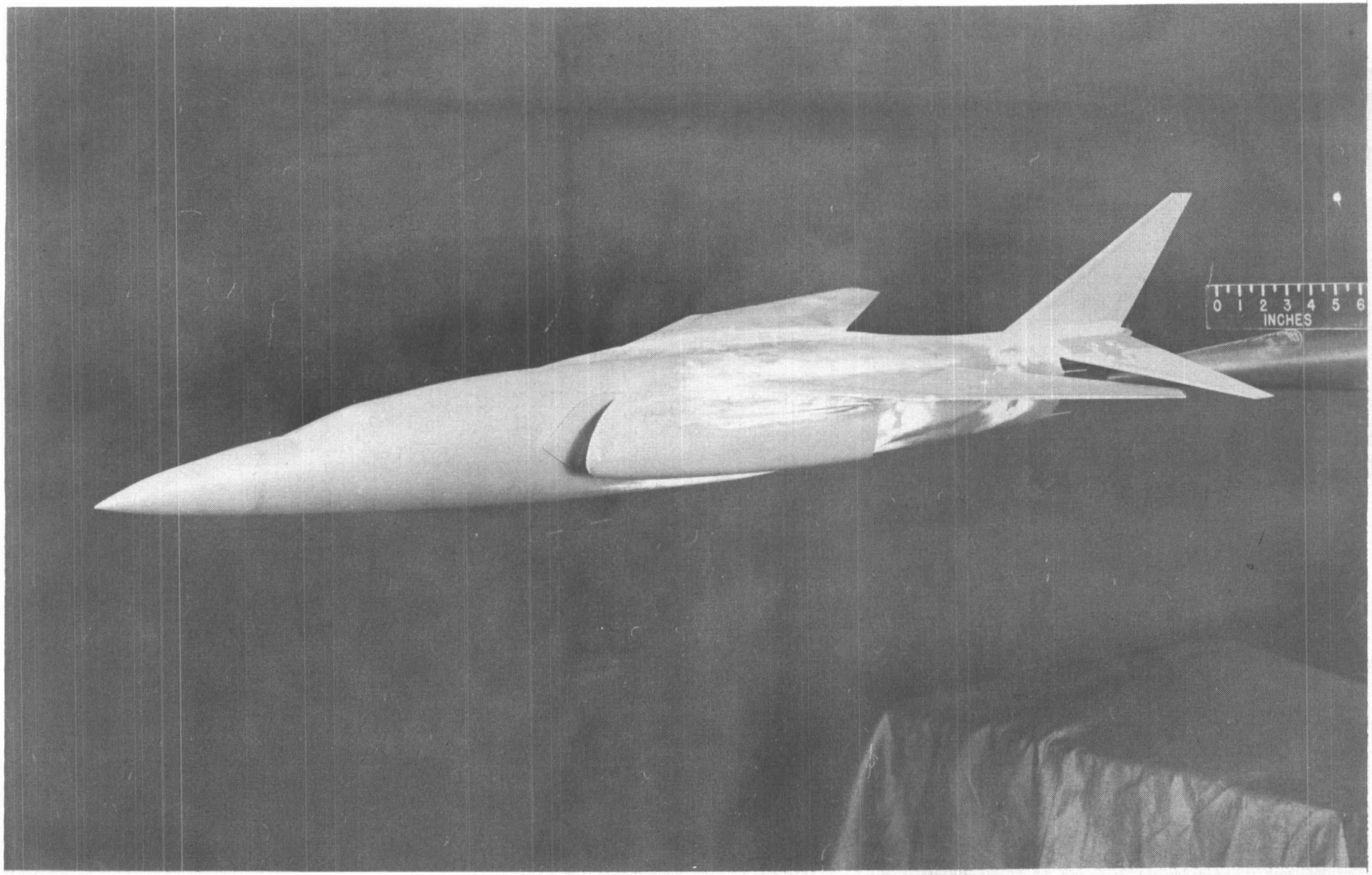


Figure 1.- Sketch of model 3. Dimensions are in inches except as noted otherwise.



(a) Plan view. $\Lambda = 75^{\circ}$. L-60-3115

Figure 2.- Photographs of model 3.



(b) Three-quarter front view. $\Lambda = 75^{\circ}$. L-60-3116

Figure 2.- Concluded.

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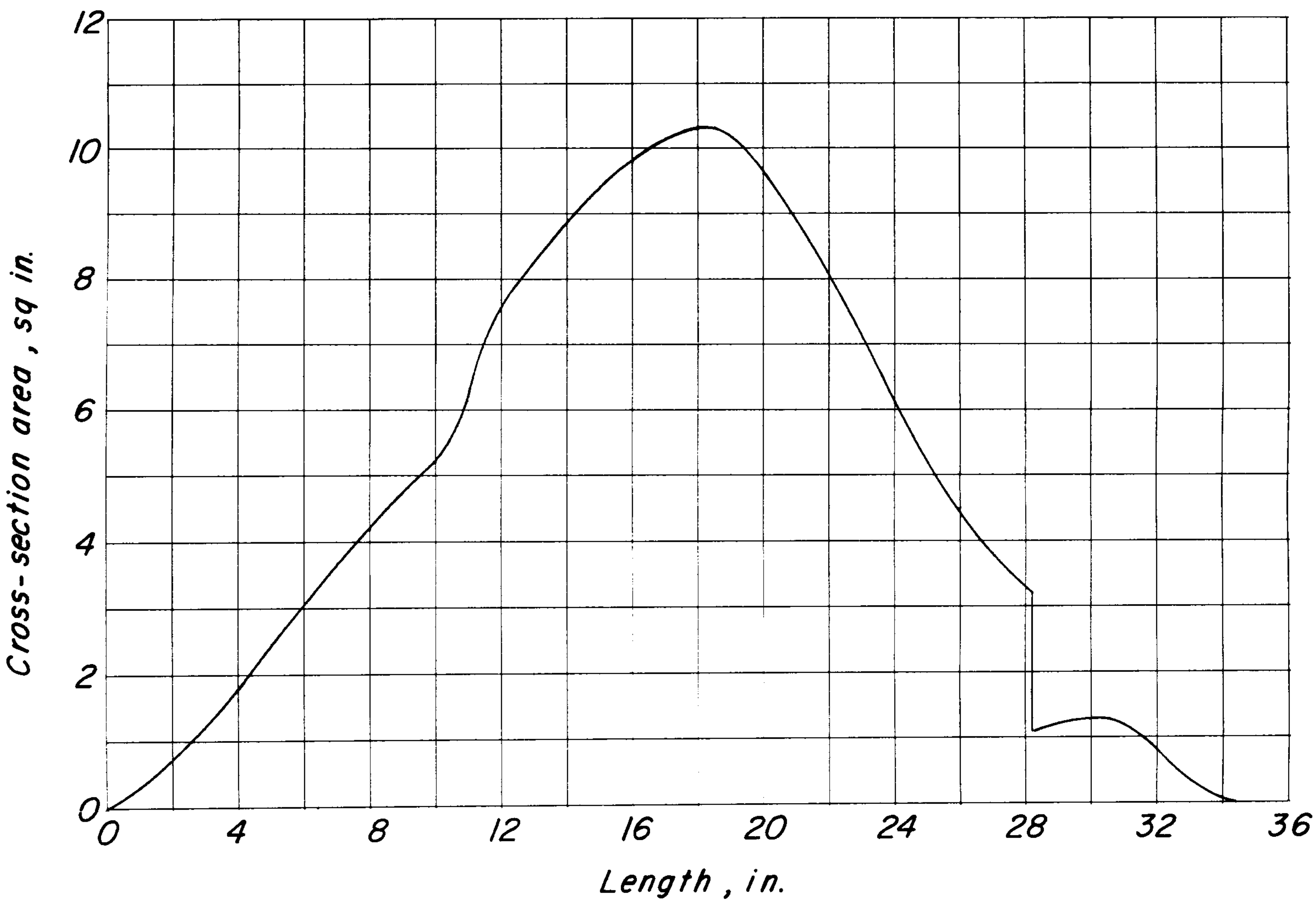

Figure 3.- Cross-section area distribution of model 3. $\Lambda = 75^{\circ}$.

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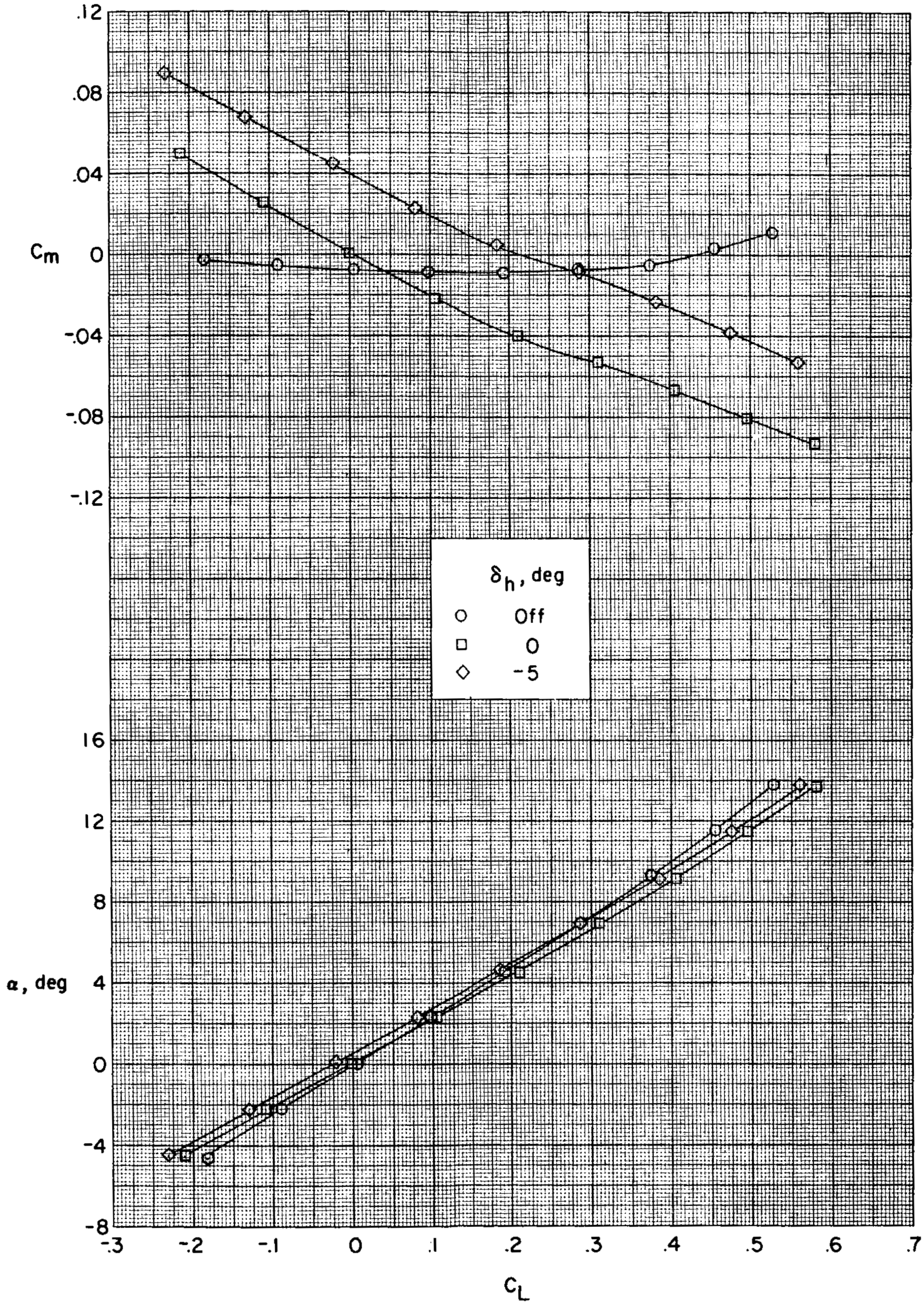
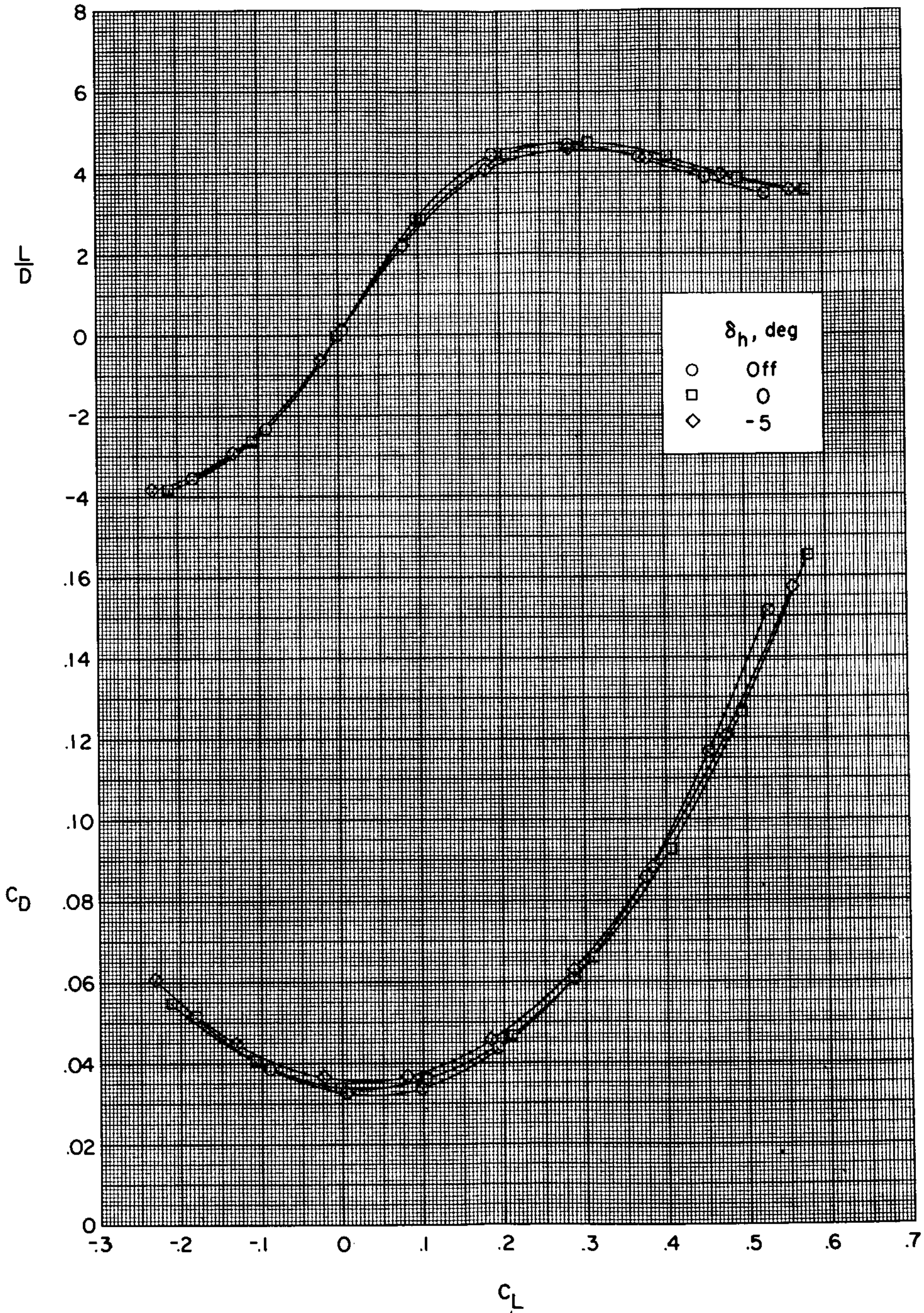


(a) Variation of C_m and α with C_L.

Figure 4.- Effect of horizontal-tail deflection on the aerodynamic characteristics in pitch for model 3. $\Lambda = 50^{\circ}$.

[redacted]



(b) Variation of L/D and C_D with C_L.

Figure 4.- Concluded.

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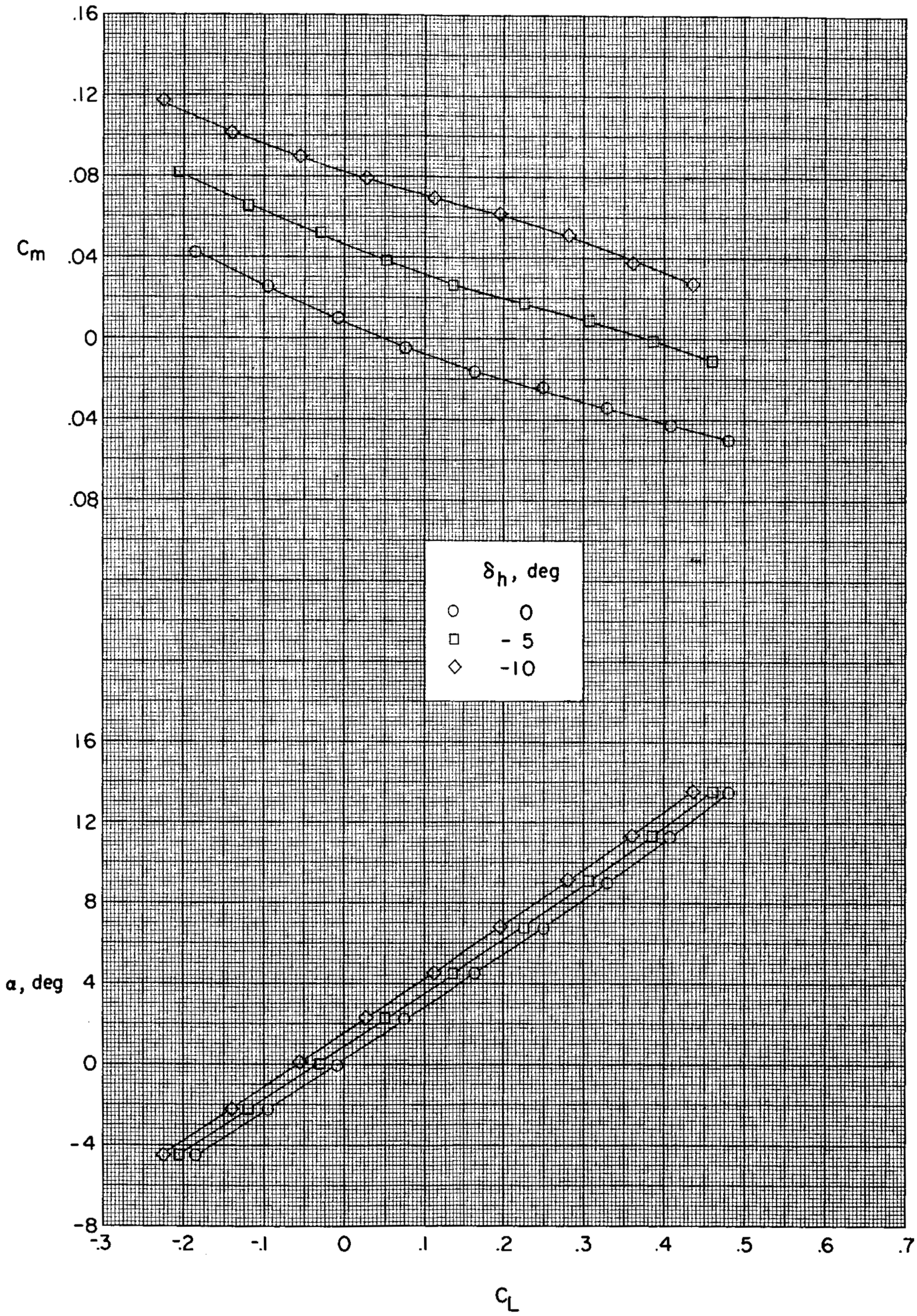

(a) Variation of C_m and α with C_L.

Figure 5.- Effect of horizontal-tail deflection on the aerodynamic characteristics in pitch for model 3. $\Lambda = 75^{\circ}$.

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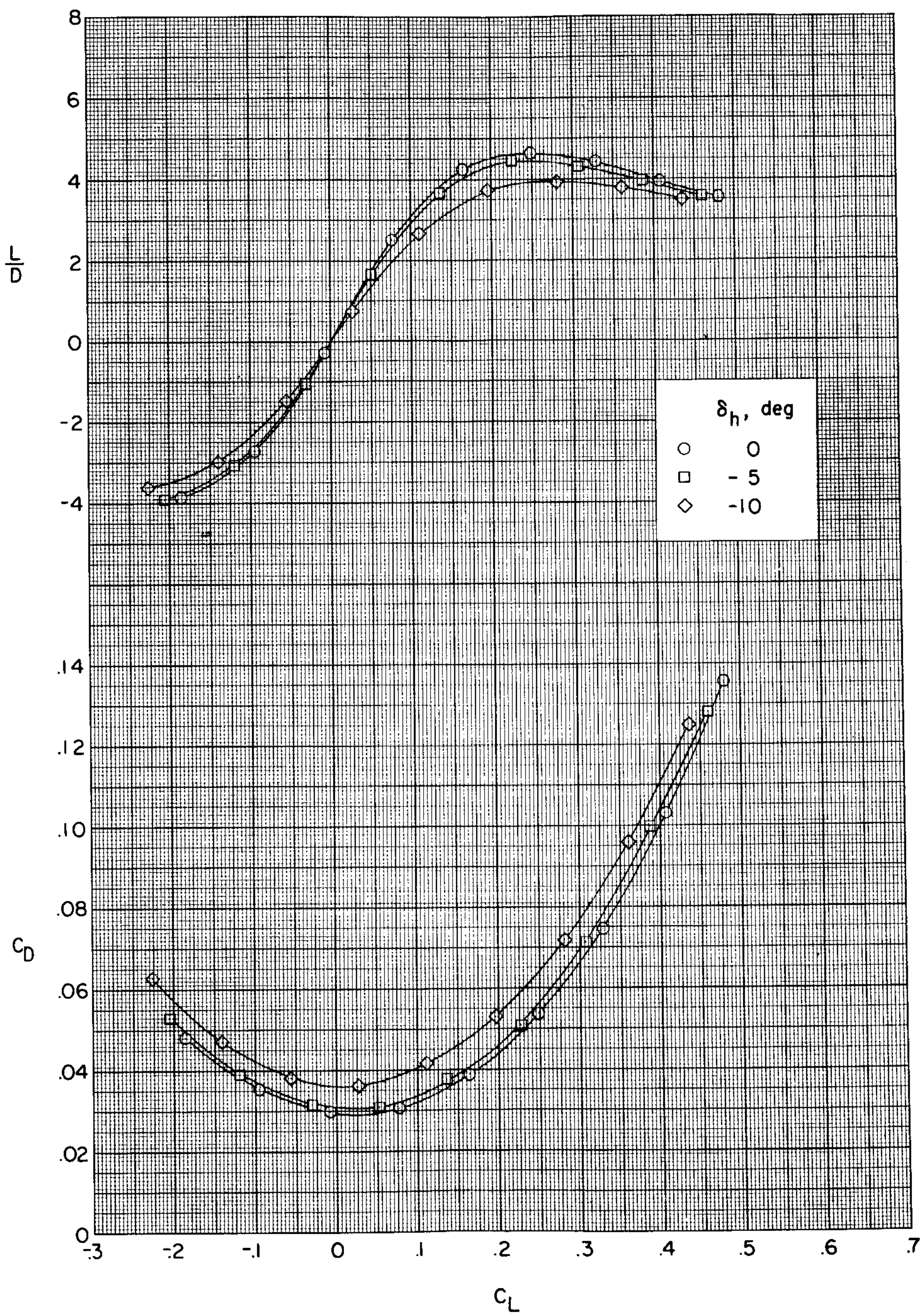

(b) Variation of L/D and C_D with C_L.

Figure 5.- Concluded.

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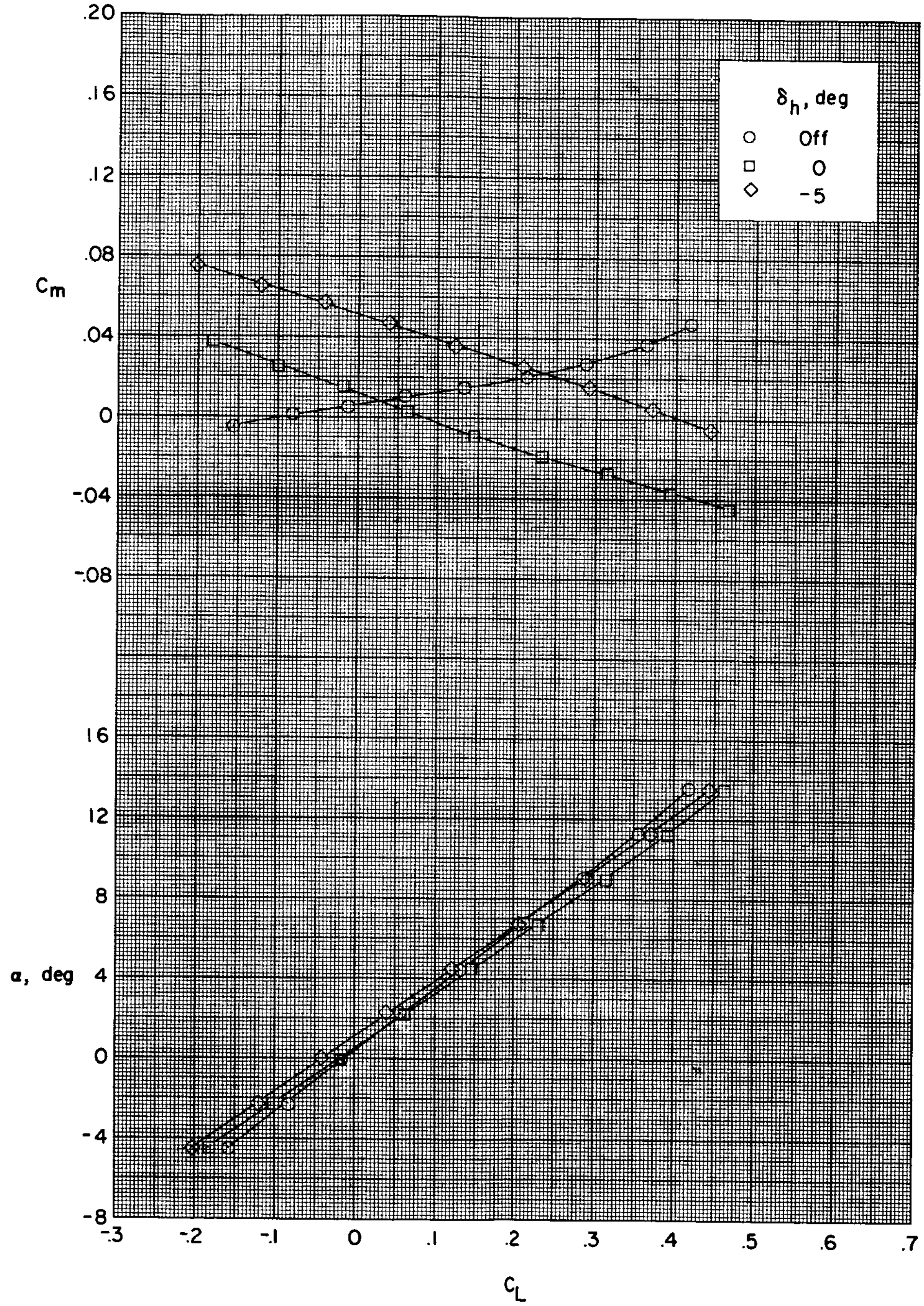

(a) Variation of C_m and α with C_L.

Figure 6.- Effect of horizontal-tail deflection on the aerodynamic characteristics in pitch for model 3. $\Lambda = 80^{\circ}$.

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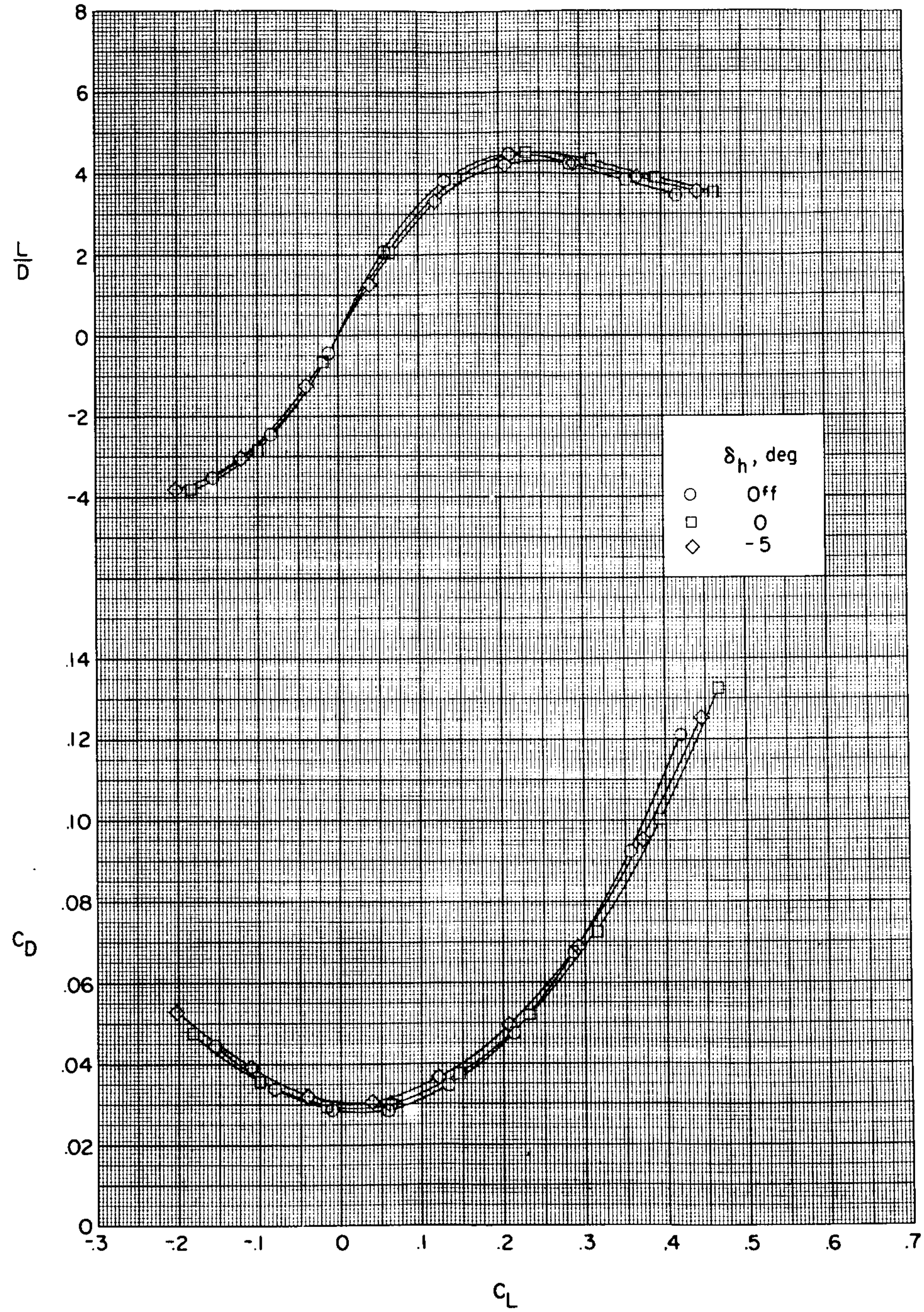

(b) Variation of L/D and C_D with C_L.

Figure 6.- Concluded.

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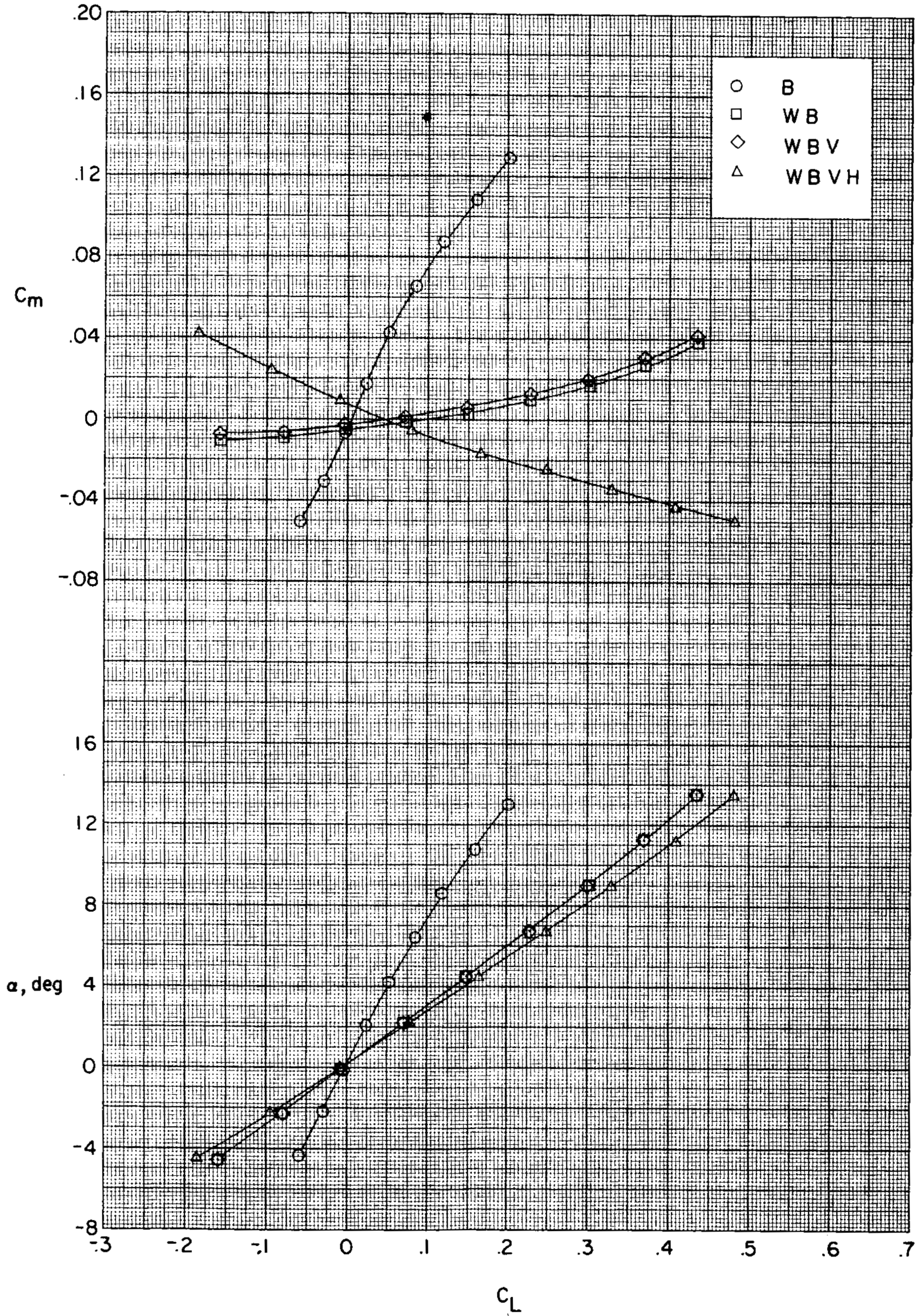

(a) Variation of C_m and α with C_L.

Figure 7.- Aerodynamic characteristics in pitch for various components of model 3. $\Lambda = 75^{\circ}$.

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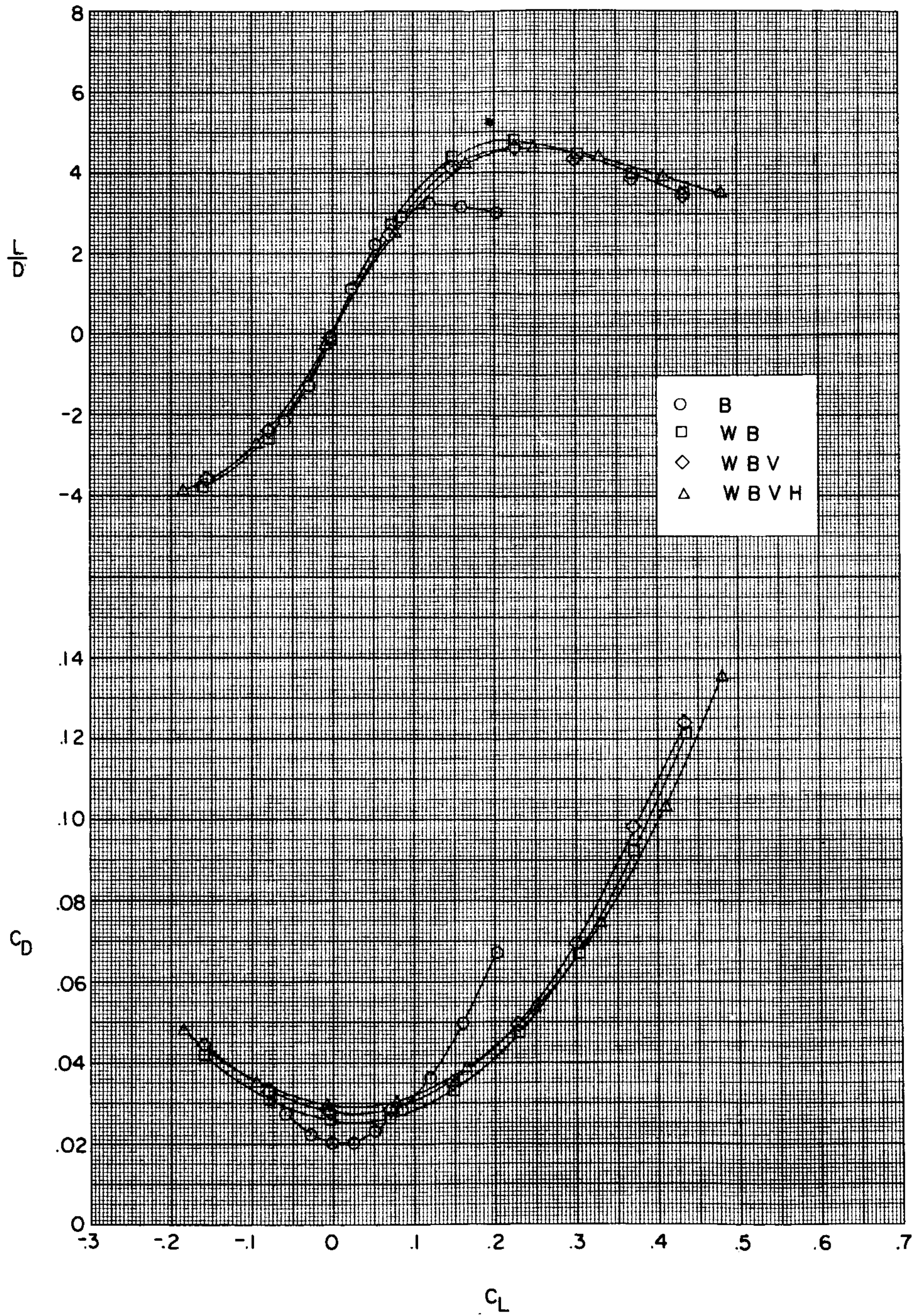

(b) Variation of L/D and C_D with C_L.

Figure 7.- Concluded.

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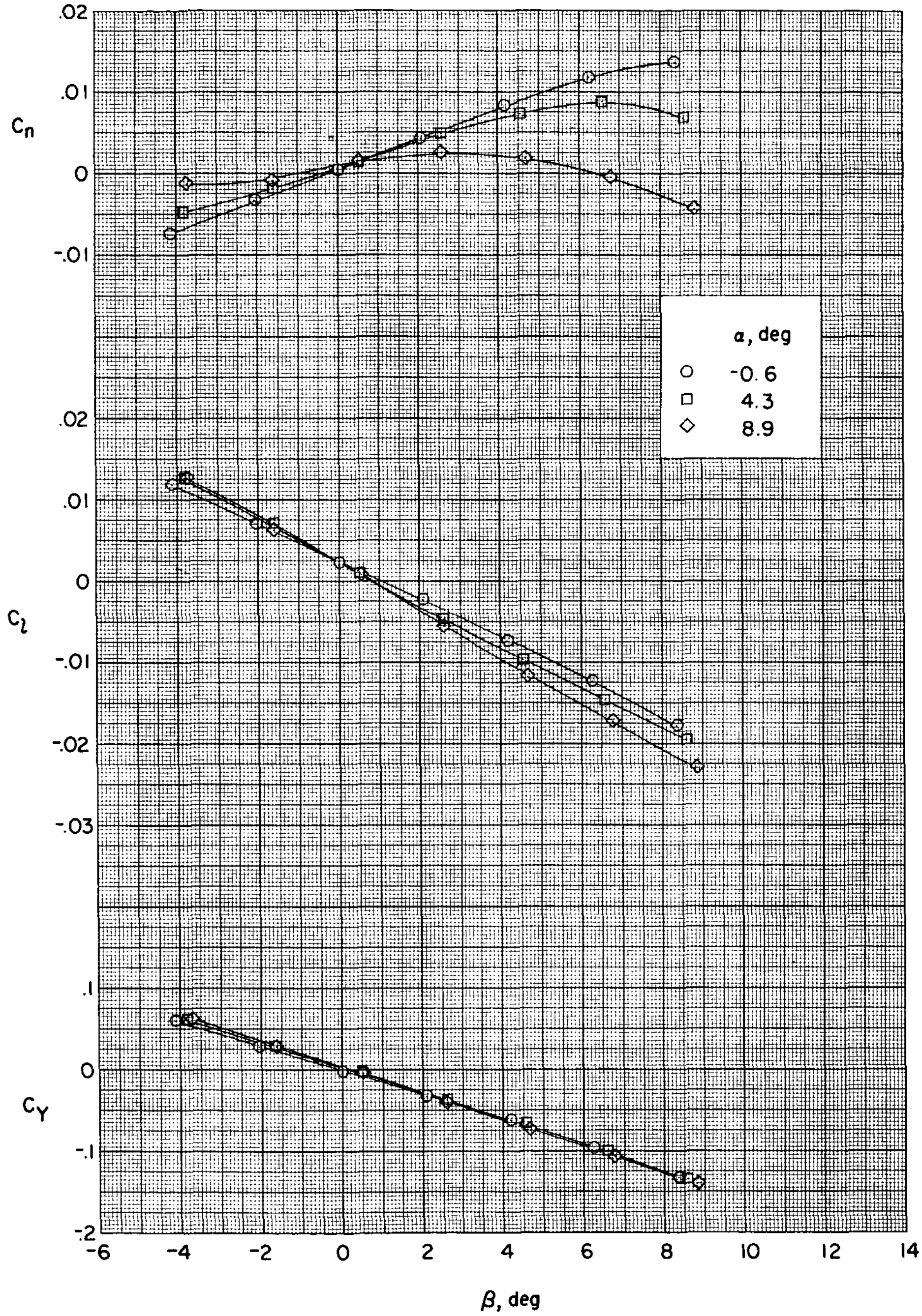

Figure 8.- Variation of aerodynamic characteristics in sideslip for model 3. $\Lambda = 50^{\circ}$.

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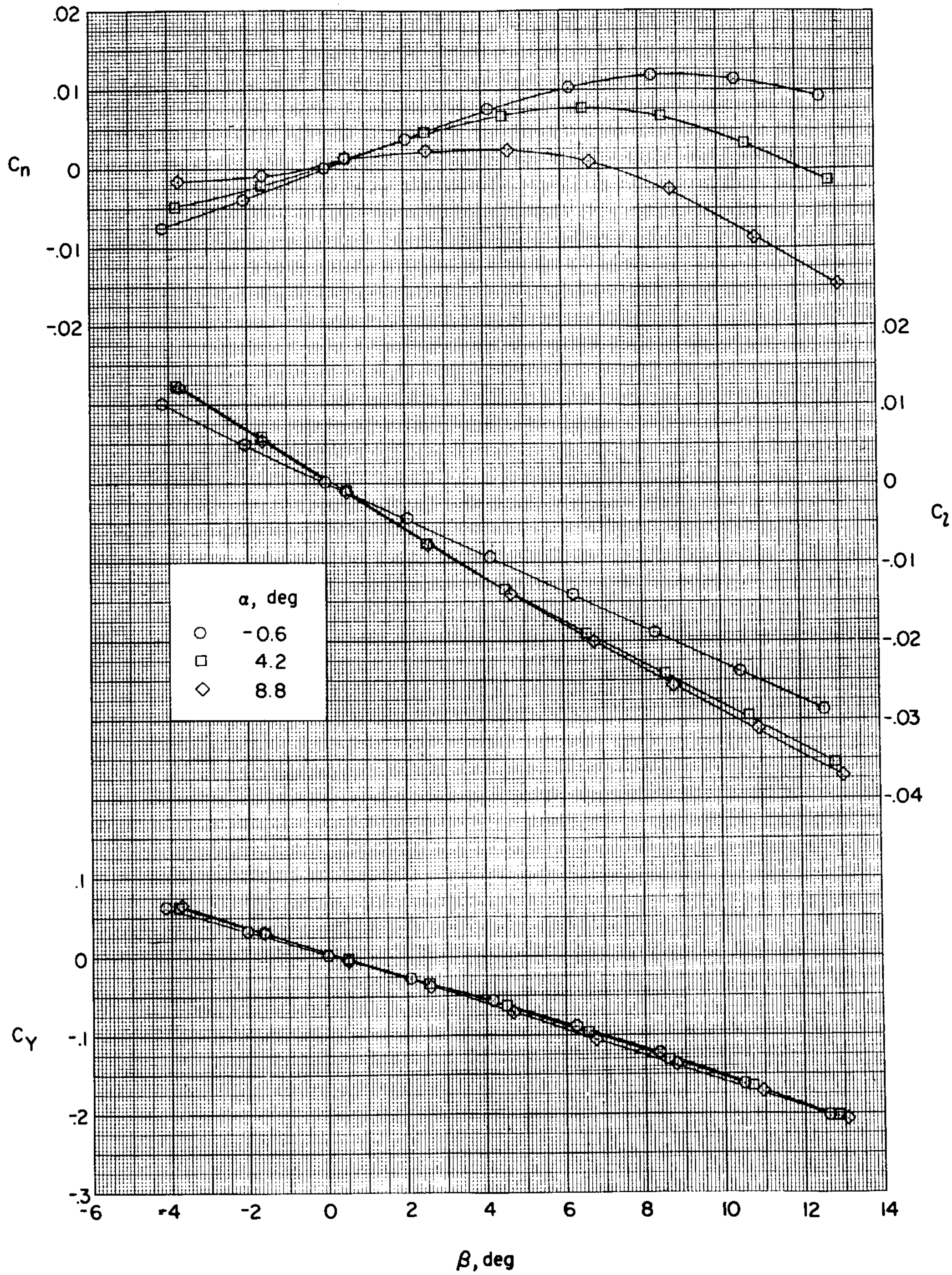

Figure 9.- Variation of aerodynamic characteristics in sideslip for model 3. $\Lambda = 75^{\circ}$.

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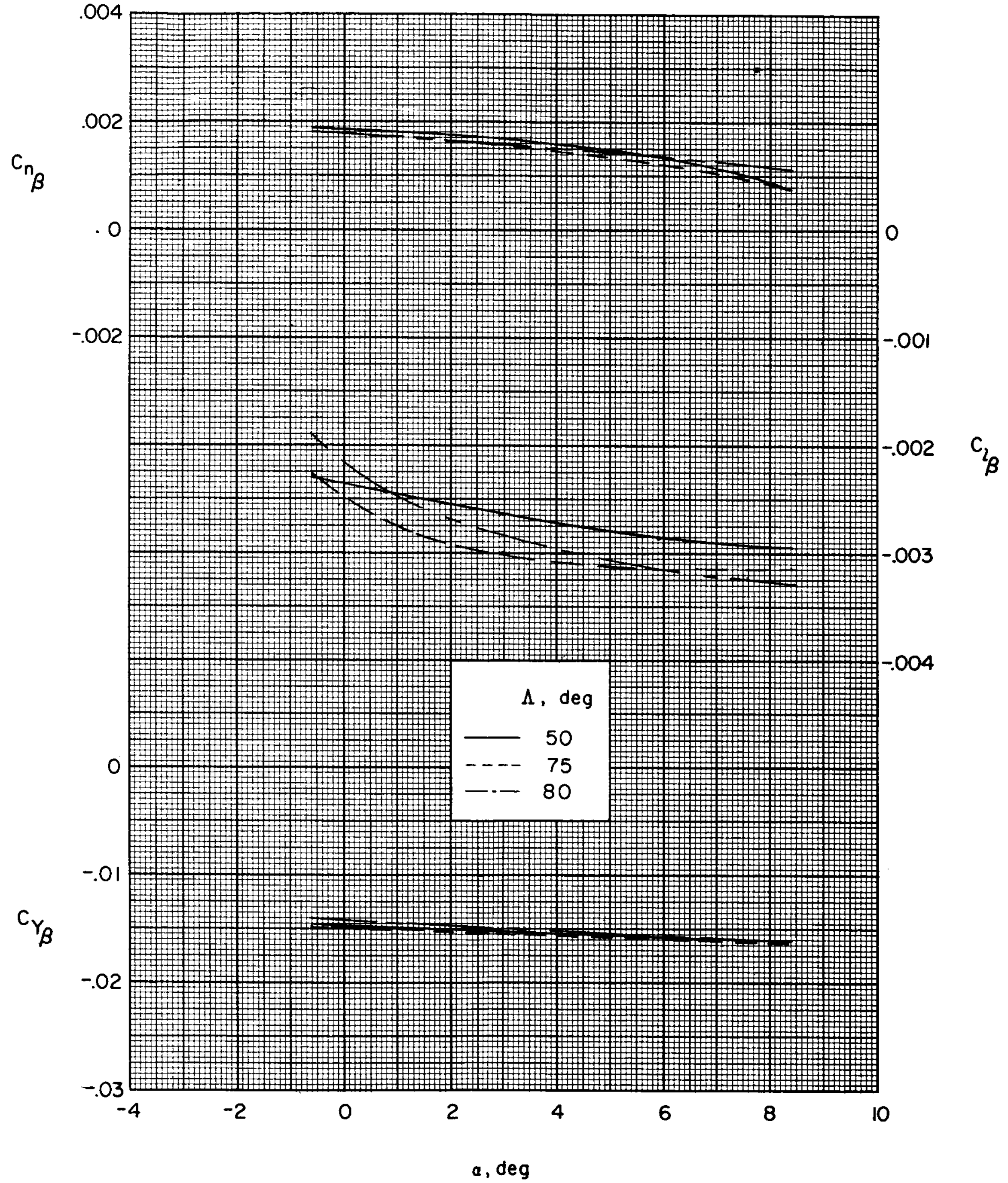

Figure 11.- Variation of lateral-stability derivatives with angle of attack for model 3 with various leading-edge sweep angles of the outboard panel of the wing.

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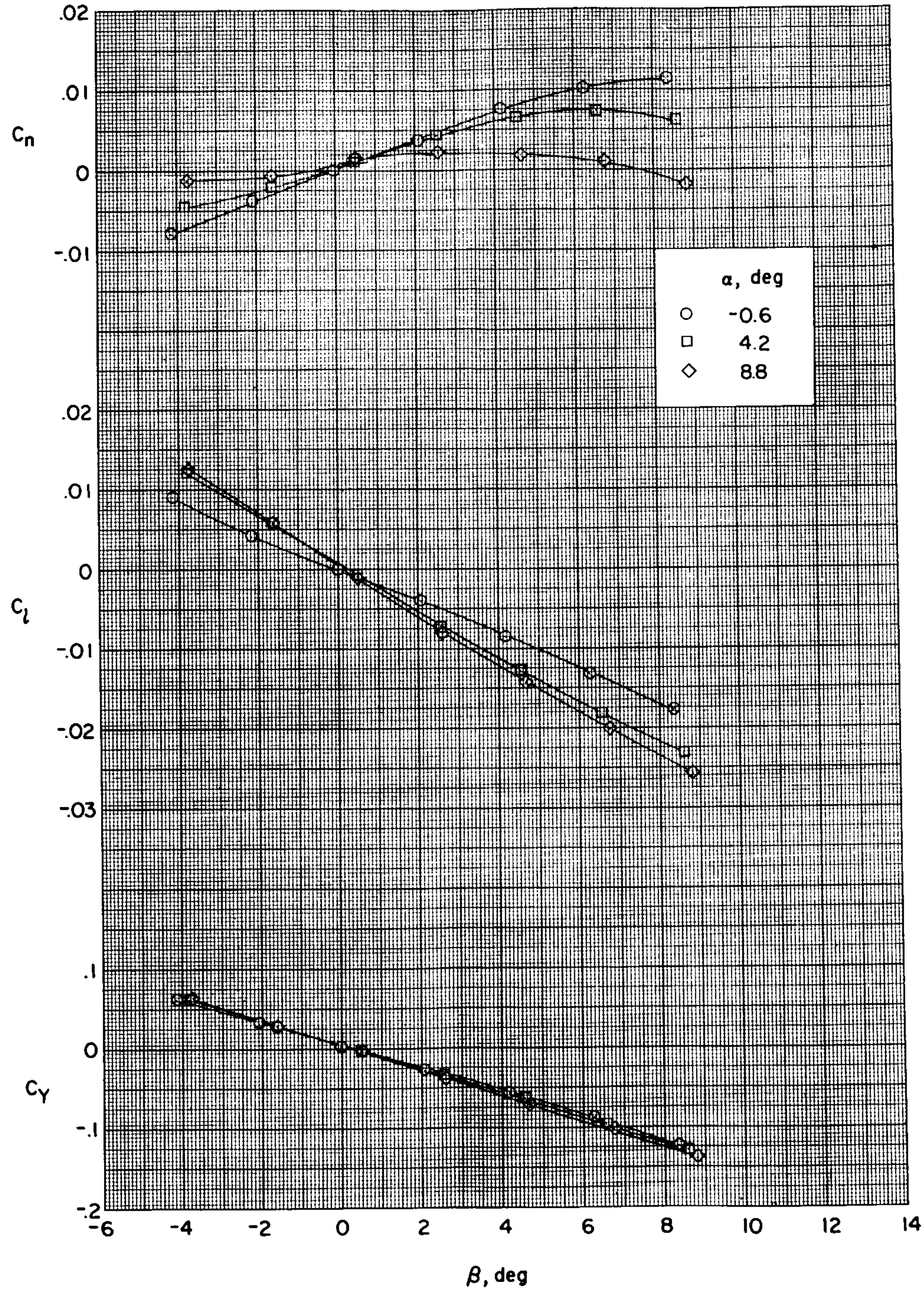

Figure 10.- Variation of aerodynamic characteristics in sideslip for model 3. $\Lambda = 80^{\circ}$.